

REMARKS

Claim 7 is amended, and claims 1, 5-9, and 13-17 are pending in the application. The Office action incorrectly lists claim 4 as pending. Claim 4 was cancelled in Amendment B.

General Considerations

The present invention relates to a crystal puller having a susceptor assembly for increasing the useful life of a susceptor disposed in the crystal puller. In conventional crystal pullers, the susceptor is made of two or more pieces of graphite to allow for expansion and contraction of the quartz crucible held in the susceptor. As a result of the multiple piece construction of the susceptor, there is often a small gap along the seam, or seams, where the susceptor pieces come together. Also, due to manufacturing specifications and tolerances associated with the manufacture of crucibles and susceptors, the crucible may not always seat within the susceptor in close contact with the entire inner surface of the susceptor. As a result, there may also be one or more gaps between the outer surface of the crucible side wall and the inner surface of the susceptor side wall, including at the annular seam between the top of the susceptor and the crucible.

At high operating temperatures in the crystal puller, such as 1500 °C, graphite reacts with quartz (i.e., fused silica) as follows:



The first reaction [1] is a solid state reaction resulting in gaseous SiO as a product, which then reacts with the graphite in accordance with the second reaction [2] to form SiC. The SiC is formed by conversion of graphite and therefore introduces stresses inside the susceptor. The stresses developed in the susceptor may result in distortion of the susceptor or otherwise render the susceptor prone to cracking or failing. The conversion of graphite also tends to substantially widen the gaps in the seams between the susceptor pieces and between the crucible side wall and the susceptor side wall and thereby promote the reaction. Thus, the formation of SiC in accordance with the chemical reaction occurring between the quartz crucible, the graphite susceptor and the SiO gas negatively effects the useful lifetime of the susceptor.

Claim 1

Claim 1 is directed to a crystal puller for producing a monocrystalline ingot comprising:

- a) a susceptor including a bottom and a side wall having an inner surface and an upper rim;
- b) a crucible for holding molten source material and including a side wall having an outer surface, said crucible being received in the susceptor and having the outer surface of the side wall disposed in generally radially opposed relationship with the inner surface of the susceptor side wall, the inner surface being **free of shielding**;
- c) the susceptor being sized such that the crucible side wall extends up to above the upper rim of the susceptor side wall

- whereby a seam is defined by the upper rim of the susceptor side wall and the outer surface of the crucible side wall;
- d) a heater in thermal communication with the susceptor and crucible for heating the crucible to a temperature sufficient to melt the source material held by the crucible;
 - e) a pulling mechanism positioned above the crucible for pulling the ingot from the molten source material held by the crucible; and
 - f) an annular sealing member adapted for seating on the upper rim of the susceptor side wall **in close contact relationship with the upper rim of the susceptor side wall and the outer surface of the crucible side wall** substantially about the entire circumference of the crucible side wall to seat over said seam to generally seal between the crucible and the susceptor any gaseous product resulting from a reaction of the crucible with the susceptor against escape from between the crucible and the susceptor thereby retarding the reaction of the crucible with the susceptor.

Claim 1 is submitted as patentable over Kalugin (SU 1,680,810), Toshiba '393 (JP 03290393) in that the references fail to show the claimed combination including **an annular sealing member in close contact relationship with the outer surface of the crucible side wall.**

Referring to the translation enclosed with Response A (filed October 16, 2002), Kalugin discloses a crystal-growing chamber comprising an upper section 1 and a lower section 2. A sealing device in the form of an annular collar 12 is provided between the upper and lower sections of the chamber. The lower section

includes a crucible 8 received within a base 9. Fig. 2 of Kalugin shows an unnumbered "ring" resting atop upper ends of the crucible and the base. There is no disclosure in Kalugin regarding the construction or function of this ring beyond the drawing. Moreover, the ring is not in contact with the outer surface of the crucible side wall.

Toshiba '393 shows a ring 16 that engages an **inner** surface of an inner quartz crucible 1 and the outer surface of an outer graphite crucible 2 to prevent the intrusion of SiO vapor between the crucibles. Toshiba '393 does not show a sealing member in close contact relationship with the outer surface of the crucible side wall.

Applicants' claimed assembly is patentable over the purported combination of Kalugin and Toshiba '393 because neither reference shows an element of the claim. Even if it is assumed that Toshiba '393 provide a teaching to make the unnumbered ring of Kalugin a "sealing member," **the combination still fails** to show or suggest a sealing member in contact with the outer surface of the crucible side wall. **It is well settled that an obviousness rejection is improper if neither reference shows an element of the claim.**

Kalugin and Toshiba '393 fail to suggest the advantages of applicants' claimed construction. Applicants' sealing member is less likely to serve as a location for SiO condensation outside the seam. Note that Toshiba '393 teaches preventing intrusion of SiO vapor into the seam, and probably leads to condensation of SiO outside the seam. Such condensation is a major cause of crystal yield loss. In contrast, applicants' sealing member is designed to prevent the escape of SiO and CO gas generated

between the crucible and susceptor, and is not likely to cause condensation of SiO outside the seam. Additionally, applicants' sealing member is less likely than the prior art rings to interfere with the function of reflectors and other structures disposed above the crucible because it does not protrude over the molten source material. Moreover, applicants' sealing member is believed to be less costly to manufacture than the prior art rings, and is also easier to install than the rings.

Claim 1 is, therefore, submitted as patentable over Kalugin and Toshiba '393 for all the above reasons.

Applicants have also reviewed the other art of record and determined that claim 1 is patentable over such art. With reference to Japanese patent abstract JP 59030794, applicants emphasize that the reference shows a susceptor inner surface that includes shielding (separating layer 4). In contrast, applicants claim 1 recites that the inner surface of the susceptor is **free of shielding**. A separating or shielding layer is likely to add cost to the assembly, and the layer may escape from the assembly and thereby contaminate the puller and the silicon melt contained in the crucible. Moreover, the abstract of the reference says nothing about sealing. Accordingly, applicants believe the application is patentable over all of the cited art.

Claims 5-8 depend directly or indirectly from claim 1 and are submitted as patentable for the same reasons as claim 1.

Claim 7 states the susceptor is constructed of at least two pieces. Applicants respectfully traverse the rejection over Kalugin and Toshiba '393 in that neither describes or suggests that the "base" or graphite crucible be made of at least two pieces.

Claim 9

Claim 9 recites a susceptor assembly comprising, among other things, an annular sealing member adapted for seating on the upper rim of the susceptor side wall in close contact relationship with the upper rim of the susceptor side wall and the outer surface of the crucible side wall substantially about the entire circumference of the crucible side wall to seat over said seam. To the extent claim 9 corresponds to claim 1, it is submitted as patentable for the same reasons as claim 1. Claims 13-16 depend from claim 9 and are submitted as patentable for the same reasons as claim 9. Claims 15 correspond to claim 7, respectfully, and are submitted as patentable for the same additional reasons.

Claim 17

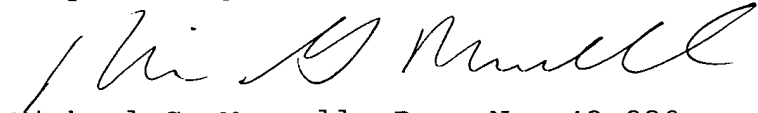
Claim 17 is directed to a method for growing monocrystalline ingots comprising, in pertinent part, by seating a sealing member on the upper rim of the susceptor side wall in close contact relationship with the upper rim of the susceptor side wall and the outer surface of the crucible side wall substantially about the entire circumference of the crucible side wall so that the sealing member seats over said seam. To the extent claim 17 corresponds to claim 1, it is submitted as patentable for the same reasons as claim 1.

CONCLUSION

Applicants respectfully request reconsideration and allowance of claims 1, 5-9, and 13-17. The undersigned requests a telephone call from the Examiner if this would expedite allowance of the application.

Applicants do not believe that any fee is required by the timely submission of this response. In any case, the Commissioner is requested to charge any fee deficiency or credit any overpayment to Deposit Account No. 19-1345 in the name of Senniger, Powers, Leavitt & Roedel.

Respectfully submitted,



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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

7 (amended). A crystal puller as set forth in claim 1
wherein the susceptor is constructed of at least two pieces, the
susceptor pieces generally abutting one another other along a
5 seam comprising a generally vertically extending segment within
[in] the side wall of the susceptor.